# Product Development Team
# for
# NEXRAD Enhancements

# Quarterly Report – 1st Quarter FY 02

**02.6.2    Polarization and Frequency Diversity**
*Continue development of algorithms that utilize polarization data to detect regions and fields of hydrometeors and non-hydrometeors, particularly those that are hazardous to aviation operations.*

a) Current Efforts

**(NSSL):**

1. Rain/snow discrimination.

Detailed analysis of the Cimarron dual-polarization radar data and corresponding surface data for the two snow events, 8 November 2000 and 27-28 November 2001, shows that rain, dry snow, and wet snow precipitation can be distinguished if the measurements of differential reflectivity ZDR and cross-correlation coefficient ?hv are made in addition to the conventional radar reflectivity factor Z. It was found also that both Z and ZDR measured by the Cimarron radar at low elevation angles are noticeably biased due to a partial radar beam blockage. These biases vary with azimuth and have to be accounted for prior to implementation of the automatic classification scheme. Accurate calibration of Z and ZDR is particularly important for cold season weather because polarimetric contrasts between rain and snow are much weaker than, for example, between rain and hail. Currently we are working on the procedure for Z and ZDR correction.

2. Identification of birds.

The statistics of the bird signature occurrence in the dual-polarization data was closely examined for the month of May 2001. It was found that the contaminated VAD NEXRAD data (flagged according to the NWS criteria) were associated either with the presence of migratory birds or convective precipitation in the radar coverage area.

3. Discrimination between sea clutter, marine stratocumulus clouds, and frontal precipitation in the coastal areas.

Note that this task is not currently part of the TD. However, this capability is serendipitously available though independent work done for the Naval Research Laboratory.

Marine stratus clouds in the vicinity of the approach zones of the airports in the Pacific Northwest region pose serious problem for FAA Traffic Management Coordinators. In the San Francisco International Airport, such clouds can prohibit dual approaches to the closely spaced parallel runways, thereby reducing airport capacity by half. Continuous radar monitoring of these low-level clouds is complicated by the their low reflectivities (usually below 5 dBZ) and by the presence of backscatter from sea surface. Sea clutter suppression in the frequency domain is not that efficient as in the case of land clutter because the former has nonzero mean Doppler velocity.

We have examined Doppler polarimetric radar data obtained from the IMPROVE I Field Experiment: Offshore Frontal Precipitation Study conducted by the University of Washington west of the Seattle, WA, area during the period 4 January - 14 February 2001. The data were collected with the NCAR SPOL 10-cm dual-polarization radar located on the Pacific shoreline at the height of 10m above sea level.

Four types of radar echo in the sea sector are easily distinguishable. The first of them is "normal" sea clutter with the range extension determined by the height and strength of evaporation duct. The second is "anomalous" sea clutter likely caused by multipath propagation attributed either to reflections from elevated layers or to strong local nonuniformities of the evaporation duct. The third is the weather echo associated with the marine boundary layer stratiform clouds that exist almost all the time in the US Pacific coast area. The fourth type of radar echo is caused by precipitating clouds that are most often associated with atmospheric fronts

It is shown that for high performance radars such as SPOL, the low-reflectivity echo from marine stratocumulus clouds is easily detected and appears as a continuation of the sea-clutter echo. However, weather and sea echoes are characterized by very distinctive polarization properties. Differential reflectivity ZDR is always positive for clouds and precipitation and is negative for sea clutter. Linear depolarization ratio LDR is usually less than -25 dB for cloud and rain drops and is 5 to 15 dB higher for sea surface at low grazing angles. Cross-correlation coefficient ?hv is very close to 1 for hydrometeors and is substantially lower for sea clutter. As a result, differential phase FDP for sea echoes has larger spatial variability compared to the weather echoes. Combining all these distinctions together, we can almost unambiguously separate weather and sea echoes if polarimetric data are available.

In the absence of polarimetric data, i.e., for unpolarized Doppler radars, such a distinction is less clear and straightforward, but possible. Although the values of

such variables as Z, mean Doppler velocity V, and spectrum width sv are not very different for weather and sea clutter, the texture of the Z and V fields (characterized by the parameters of their spatial spectra) exhibits pronounced differences that can be efficiently used for discrimination. A dual-polarization radar can serve as a validation tool for any alternate, non-polarimetric classification technique.

**(NCAR)**: To be included in a later addendum.

b) Planned Efforts

NSSL: Continue development of improved techniques.

NCAR:

d) Interface with other Organizations

None.

e) Activity Schedule Changes

None.

**02.6.3    Circulations**
*Display the NSSL Mesocyclone Detection Algorithm (MDA) and Tornado Detection Algorithm (TDA) output to Corridor Integrated Weather System users to establish utility for Terminal Convective Weather Forecast (TCWF) and National Convective Weather Forecast (NCWF) aviation users.*

a) Current Efforts

No progress to report. Task is set to begin 01 Aug 02.

b) Planned Efforts

To begin 01 Aug 02.

c) Problems/Issues

None.

d) Interface with other Organizations

None.

e) Activity Schedule Changes

None.

**02.6.4    Technical Facilitation**

*Continue to develop software infrastructure and tools required for the development and testing and display of NEPDT algorithms.*

a) Current Efforts

The WDSS2 system was enhanced in several ways to support various research efforts at NSSL, to implement new visualization techniques and to access new types of data.

1) Radar elevation scans are available, in addition to polar and PPI products, packaged as virtual volumes. This helps in the development of rapid update algorithms.

2) An information-rich, but intuitive virtual volume displaying capability (Fig. 1).
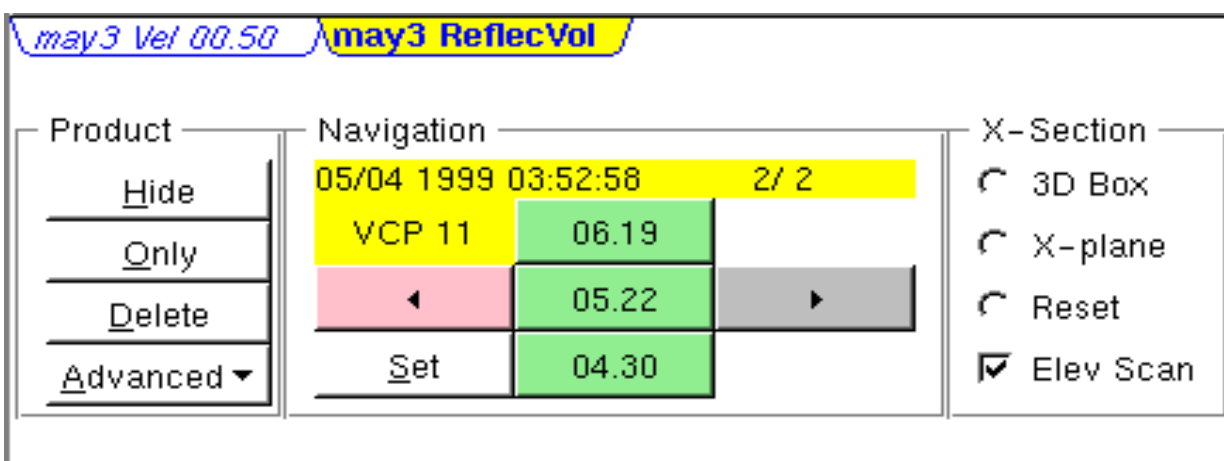


Figure 1. Virtual volume control panel.

Currently, the user is viewing the 5.22 degree elevation. The next elevation up is the 6.19 degree one and it is new (green). The previous 5.22 degree elevation is available but it is old (red). The next 5.22 degree elevation is not yet available (gray). Clicking on any of those buttons takes the user to the appropriate elevation. Notice how the colors change when looking at a product from an earlier volume (not the most current, Fig. 2).

In Fig. 3, the behavior of the virtual volume in real-time is displayed.

When the volume updates, the control panel changes to that in Figs. 4a and b.This works, in addition to radar virtual volumes, for 3D gridded products that update level-by-level.

3) Persist state of display. The display "remembers" the data sets, time and products the user was viewing and returns to the same position. In theory, an unlimited number of such configurations can be saved and returned to.
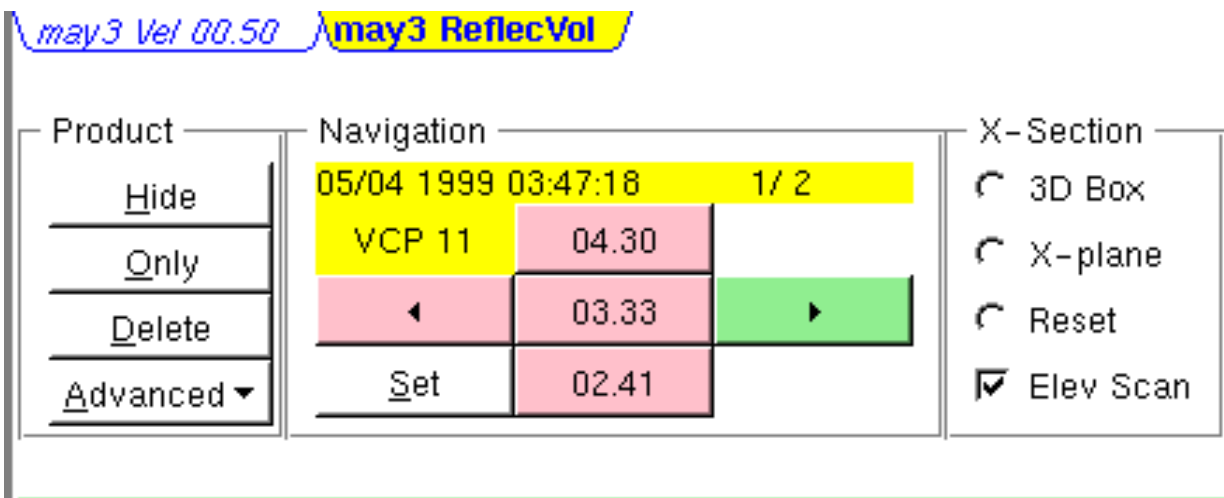
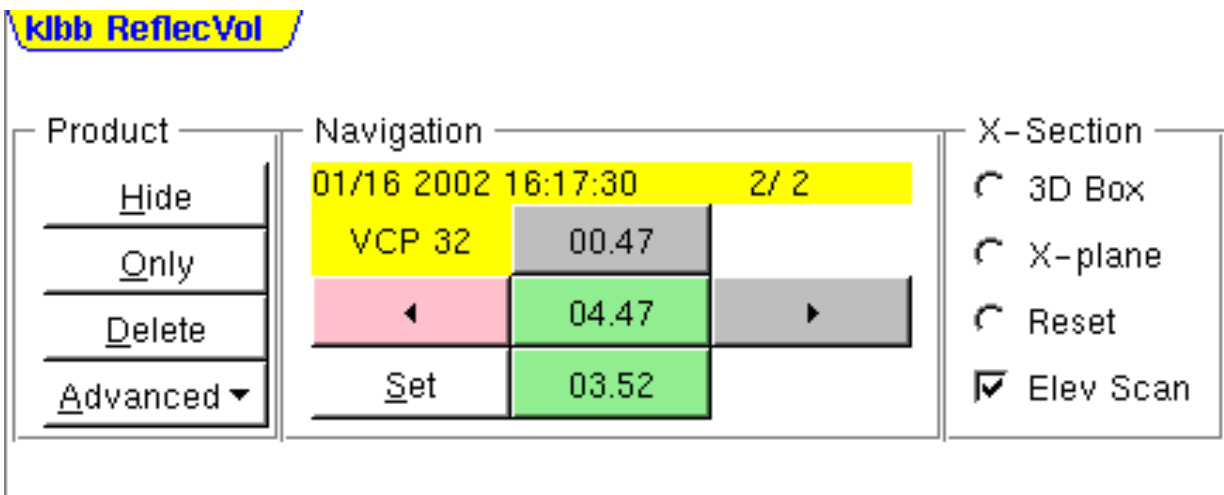Figure 2. Virtual volume control panel appearance when non-current volume is displayed.



Figure 3. Virtual volume control panel for most surrent volume.

4) To enable quick development of images such as for placing on the web:

a) a fast snapshotting facility was implemented into the display.
b) colorbars were added to the image itself.
c) An indication of time was added to the image.
d) An application that updates in real-time and produces gif images was implemented.

An example is shown in Fig. 5.

5) A simulator that will feed data from multiple archived datasets (even if they are from different sources) as if in real-time has been developed. This helps in the development of multisensor algorithms.
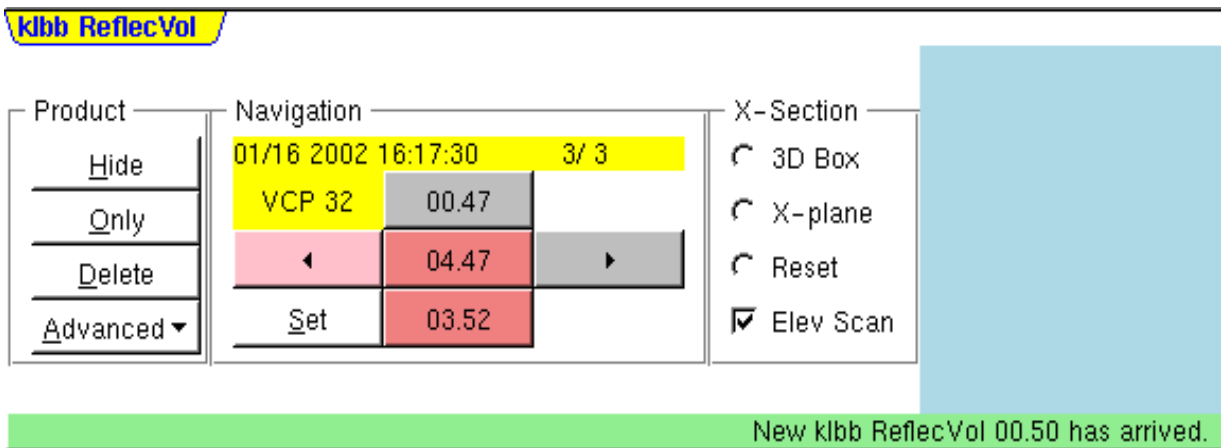
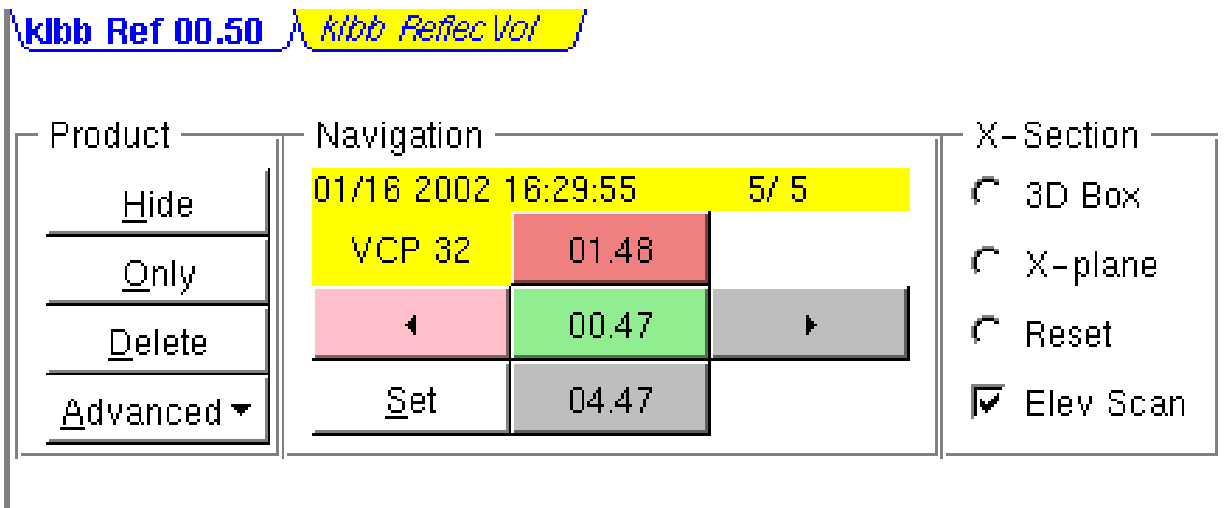Figure 4a. Virtual volume control panle prior to new volume update.



Figure 4b. Virtual control panle after new voume update.

7) Virtual volume 3D. The virtual volume display was enhanced to provide the capability to do 3D examination of the volume (Figs. 6a, b, and c).

8) A GIS-query interface was implemented so that if a user clicks on any location on the earth's surface, the closest algorithm detections are provided (Fig. 7).

9) Mesonet data can now accessed by algorithms and by the display (Fig. 8).

b) Planned Efforts

Continue display interface and capability devlopment and enhancement.
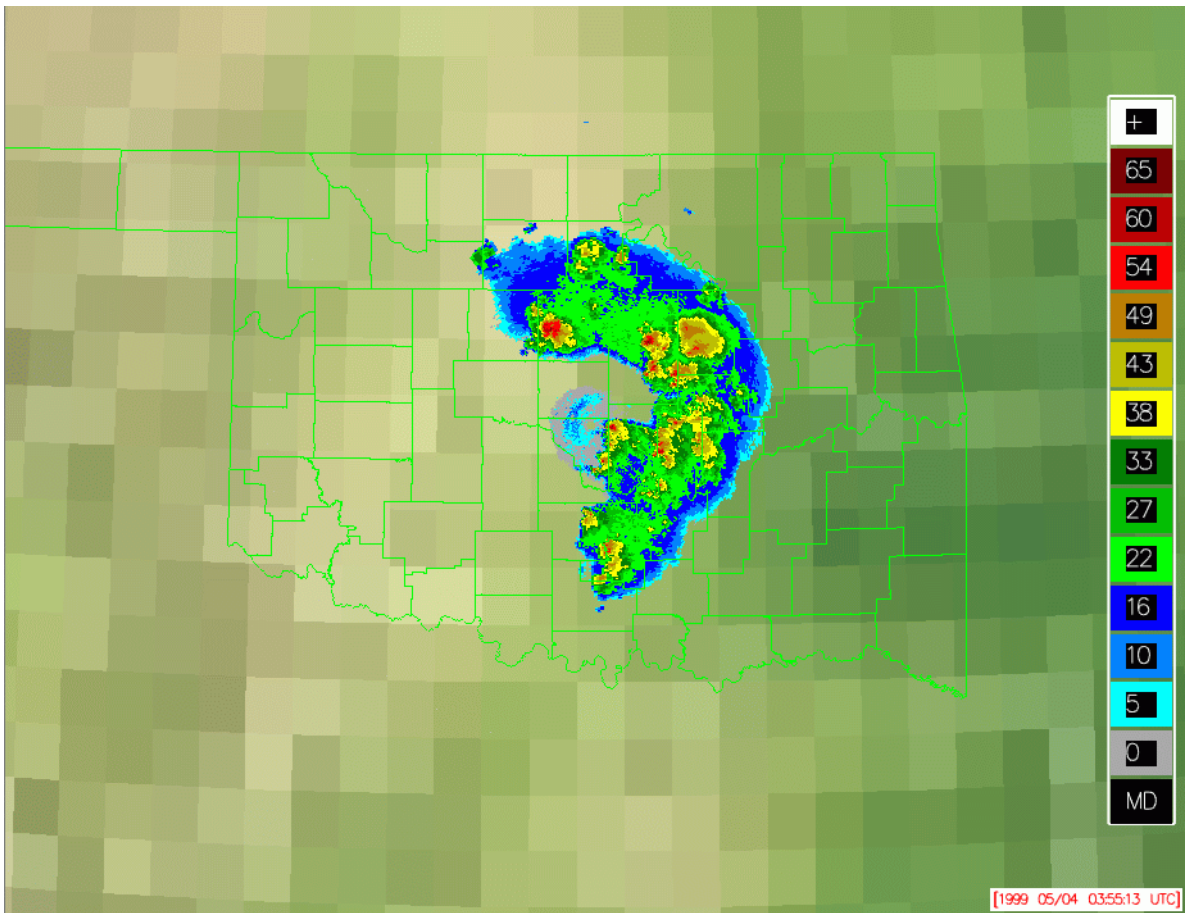
Figure 5. Example of a quick-development image suitable for the web.

<u>c) Problems/Issues</u>

None.

<u>d) Interface with other Organizations</u>

None.

<u>e) Activity Schedule Changes</u>

None.

**02.6.9    Composite Products**

*Composite Products - develop a high-resolution multi-radar product with nested reso-
lutions from 500 m to 5 km, that runs in a large analysis domain (such as CIWS), and
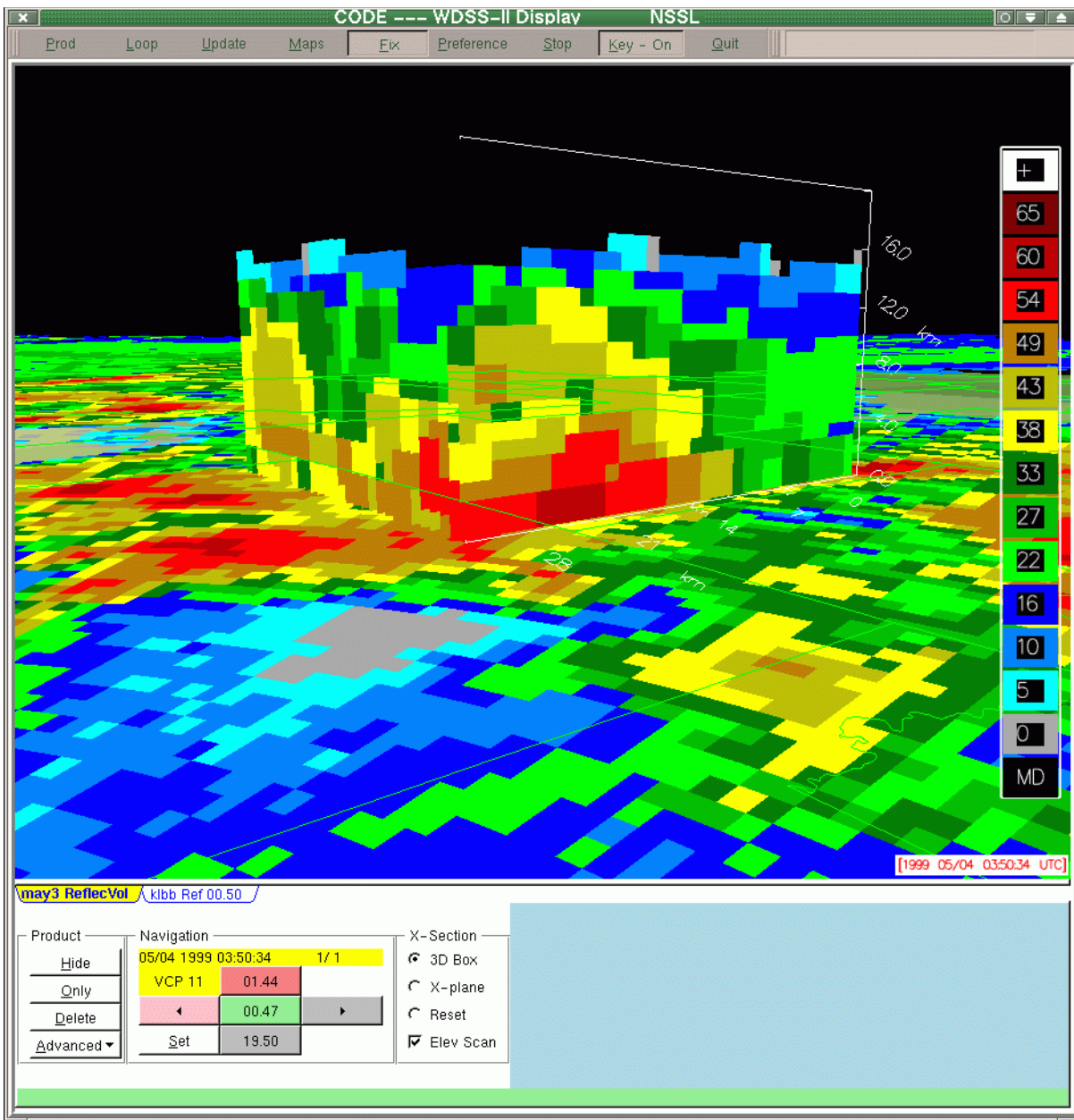that is updated at no more than 240 s intervals.*

Figure 6a. Improved virtual 3D volume example.

a) Current Efforts

Activities for this task will start 1 March 2002.

b) Planned Efforts

Begin to ingest TDWR (Terminal Doppler Weather Radar) data. Convert TDWR data into a common format (e.g., *Net*work *C*ommon *D*ata *F*ormat, or, NetCDF) that will be used for ingesting both TDWR and WSR-88D (Weather Surveillance Radar-1988 Doppler) data in various storm algorithms.
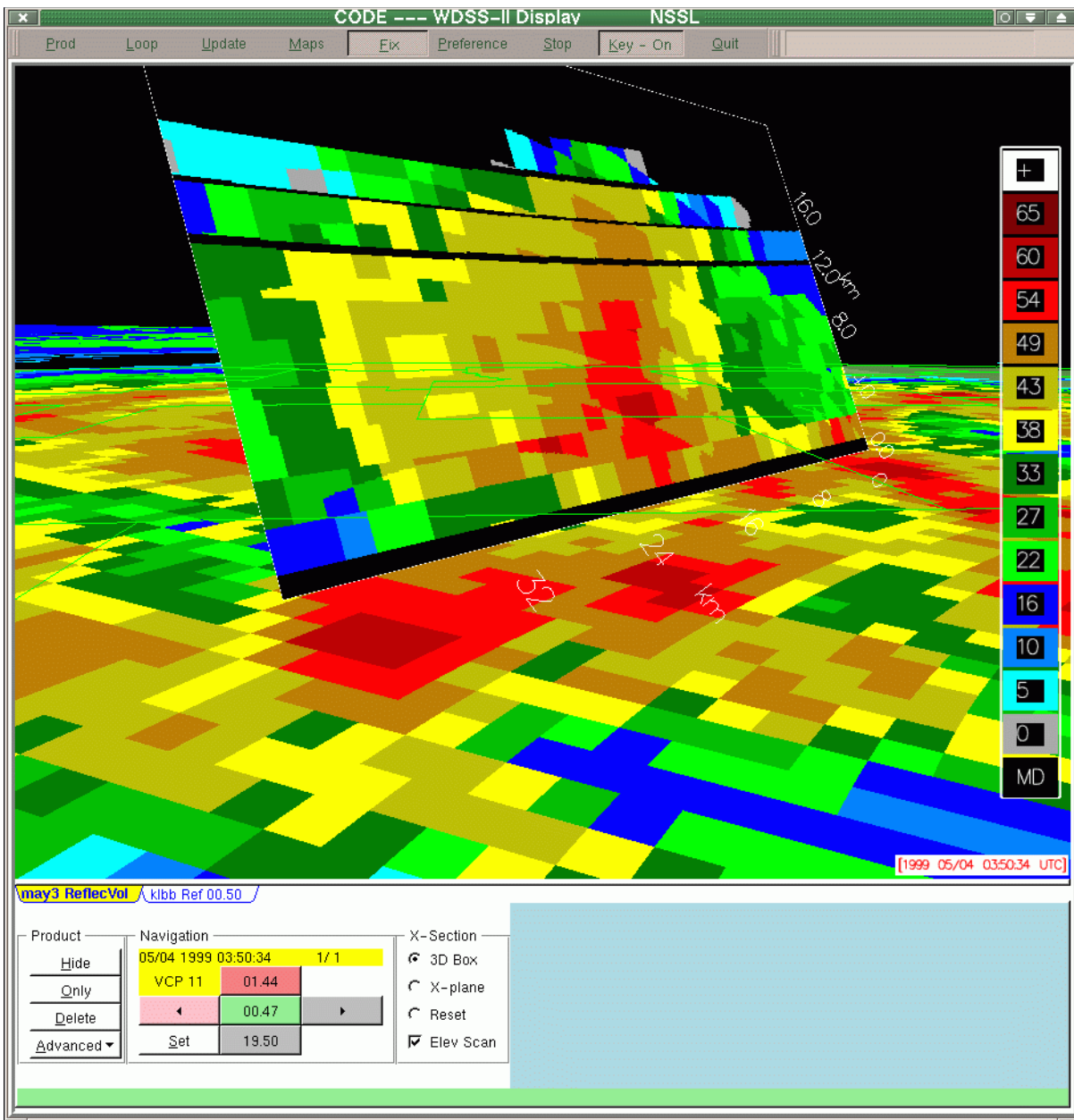
Figure 6b. Example of arbitrarily-oriented cross section supported by new vertula 3D volume.

c) Problems/Issues
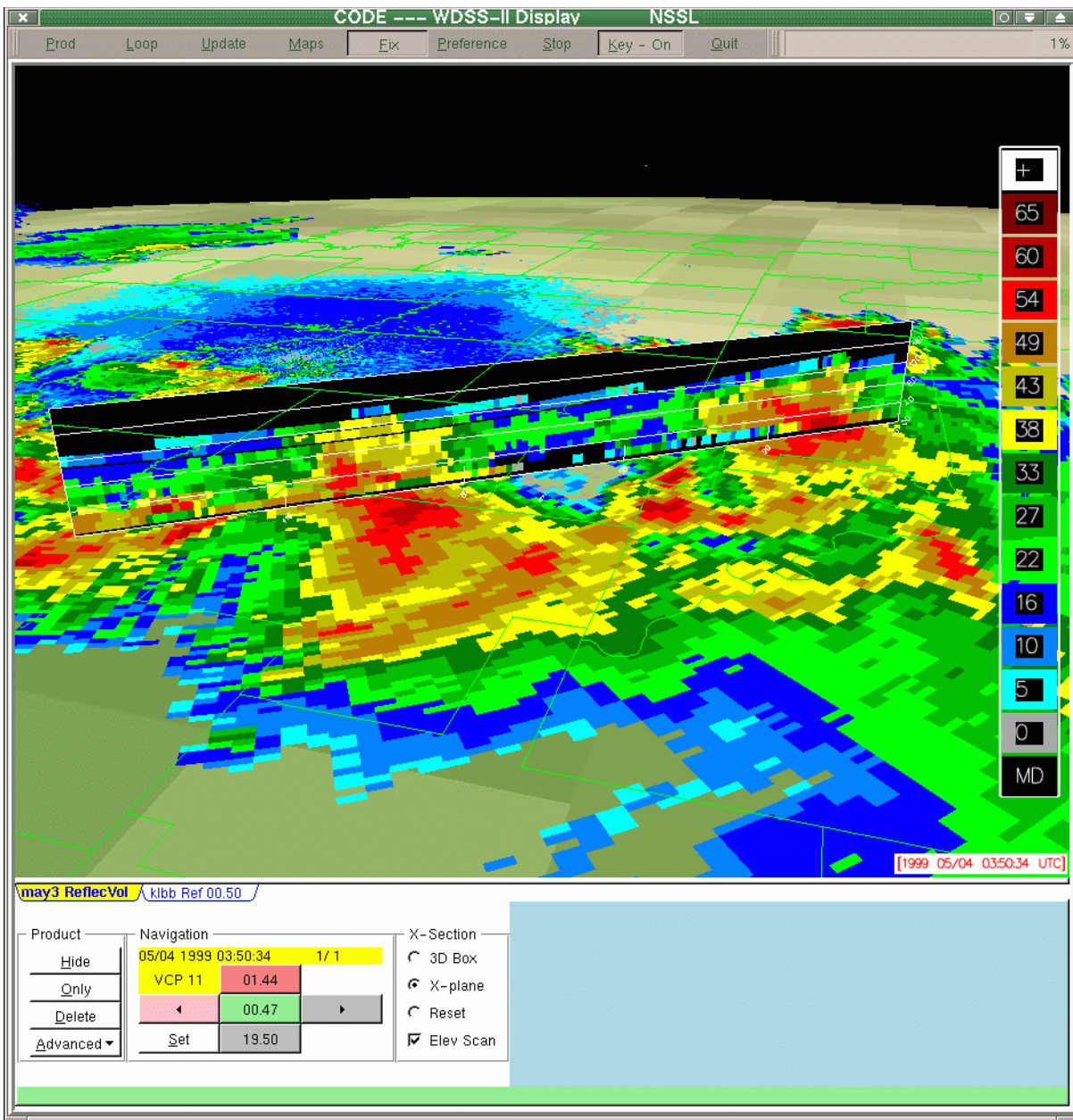
None.

d) Interface with other Organizations

None.

Figure 6c. Example of arbitrary vertical cross section supported by new virtual 3D volume.

e) Activity Schedule Changes

None.

## 02.6.11 Volume Coverage Patterns

*Volume Coverage Patterns - develop and implement new VCPs to meet the WSR-88D coverage needs of the aviation community and the AWR PDTs.*
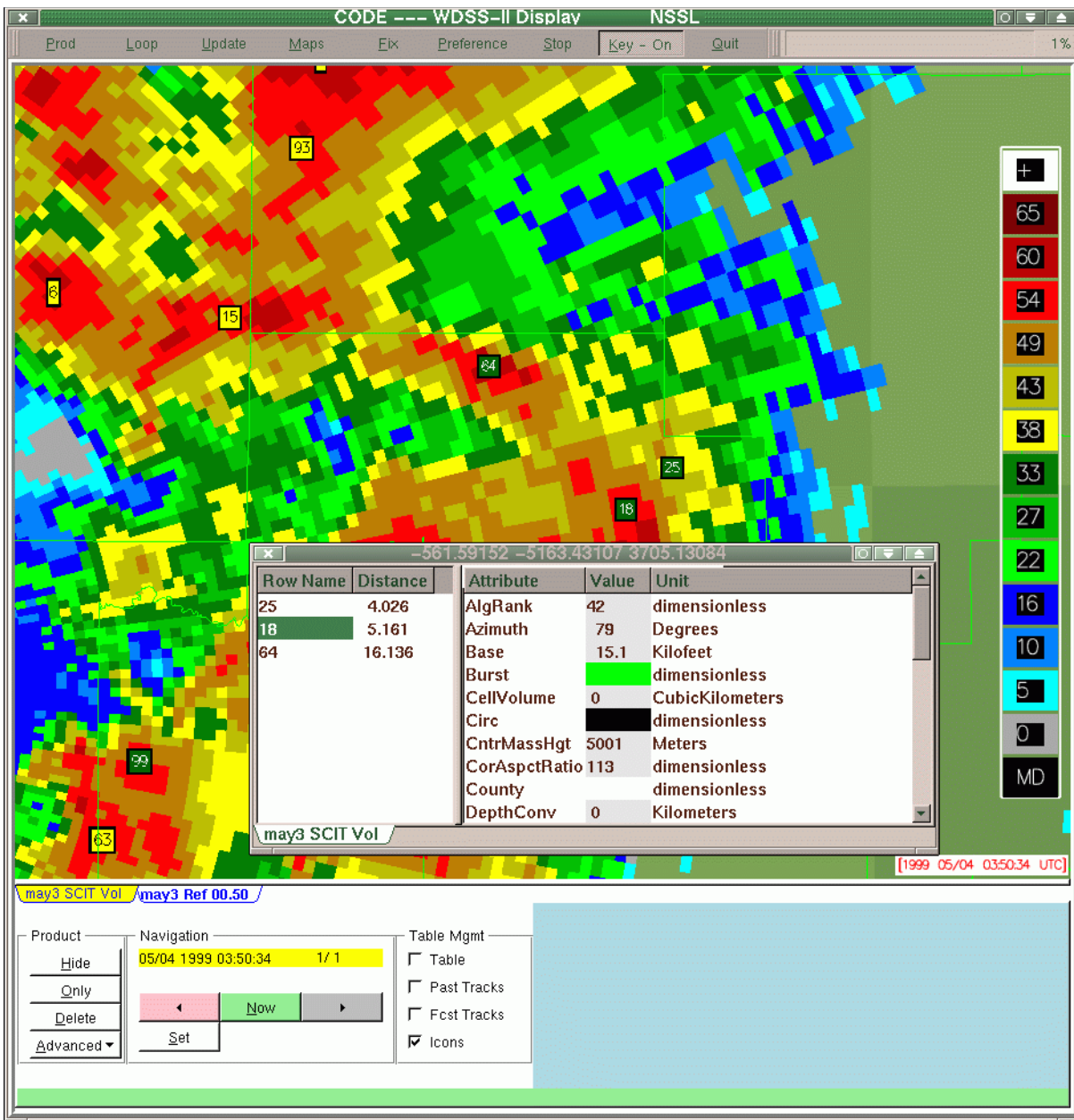
Figure 7. Arbitrary GIS query interface example.

a) Current Efforts

During this quarter, new VCP data were collected on the following dates:

10/09/01 Severe convection, collected VCPs 45,61,46
10/10/01 Convective event, collected VCP 46
10/12/01 Convective event, collected VCP 45
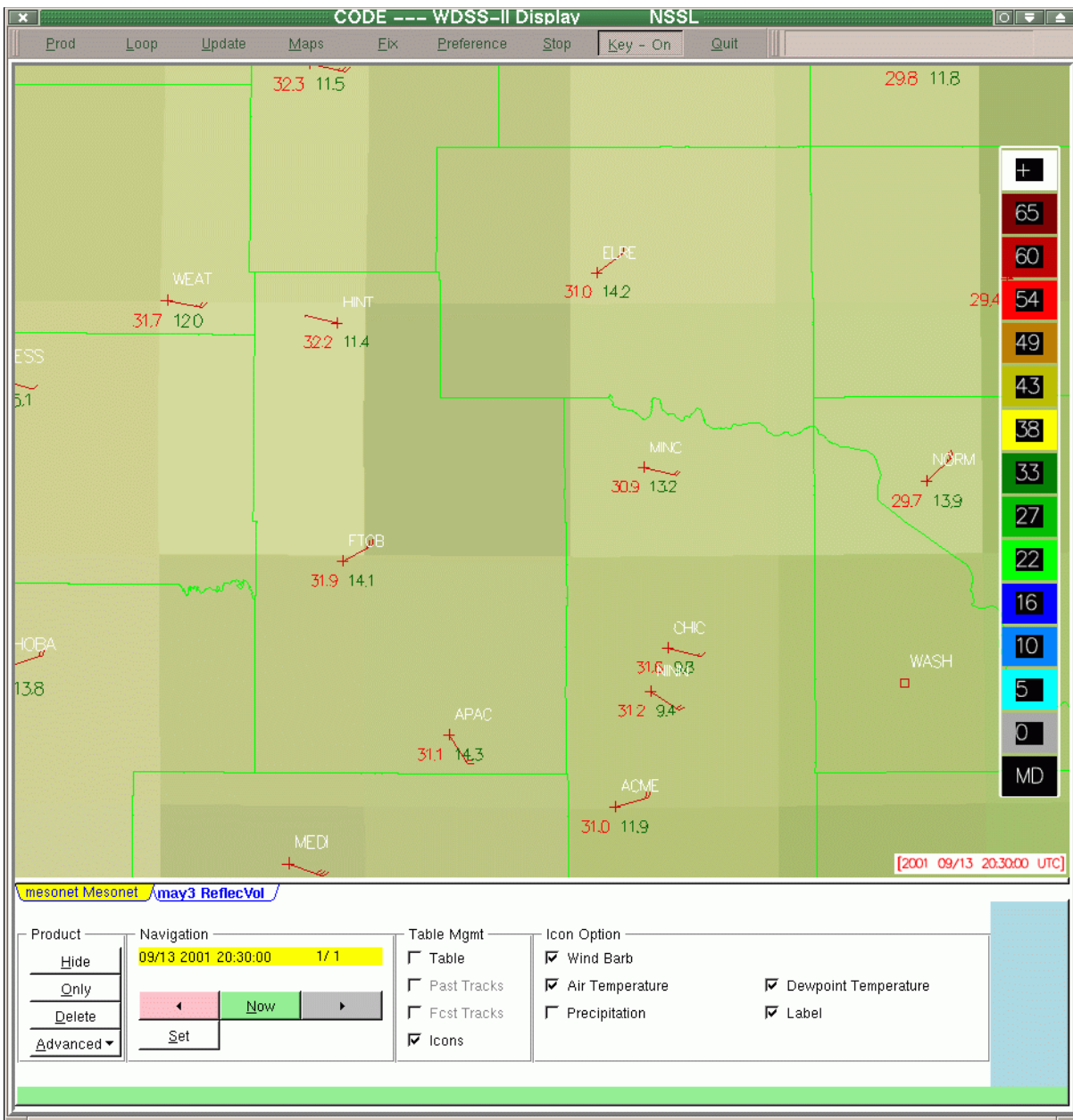11/28/01 Snow event, collected VCP 56

Figure 8. Example of overlaid mesonet data.

b) Planned Efforts

Continue analysis and data collection on new VCP's. In particular, check that current algorithms are compatible with new VCP's, and correct any incompatibilities.

c) Problems/Issues

None.

d) Interface with other Organizations

None.

e) Activity Schedule Changes

None

**02.6.12  Product Implementation**
*Explore and define aviation-specific products and implementation paths appropriate for NEPDT efforts.*

a) Current Efforts


b) Planned Efforts


c) Problems/Issues

None.

d) Interface with other Organizations

None.

e) Activity Schedule Changes

None

**02.6.14  Multi-radar Composites**
*Examine aspects of multiple radar integration and algorithms.*

a) Current Efforts

The activities for the current quarter include a couple of conference calls with the CWPDT (Drs. Marilyn Wolfson and Cindy Muller).  Future steps regarding the 3-D reflectivity mosaic for the FAA projects were briefly discussed during the calls.  We provided the CWPDT with example 3D mosaic data from the Oklahoma domain and a C++ data decoder.  Also provided to the CWPDT are a detailed documentation about the example data and two conference papers that describe the 3D reflectivity gridding and mosaicking techniques.

Two major precipitation cases (one for summer and one for winter) have been identified for the FAA CIWS domain.  Level-II data tapes from seven WSR-88Ds (KBUF, KCLE, KDTX, KIWX, KILN, KLOT, KPBZ) have been collected.  Initial

analysis domain for running the 3D mosaic has been setup (Fig. 1).  It is pro-
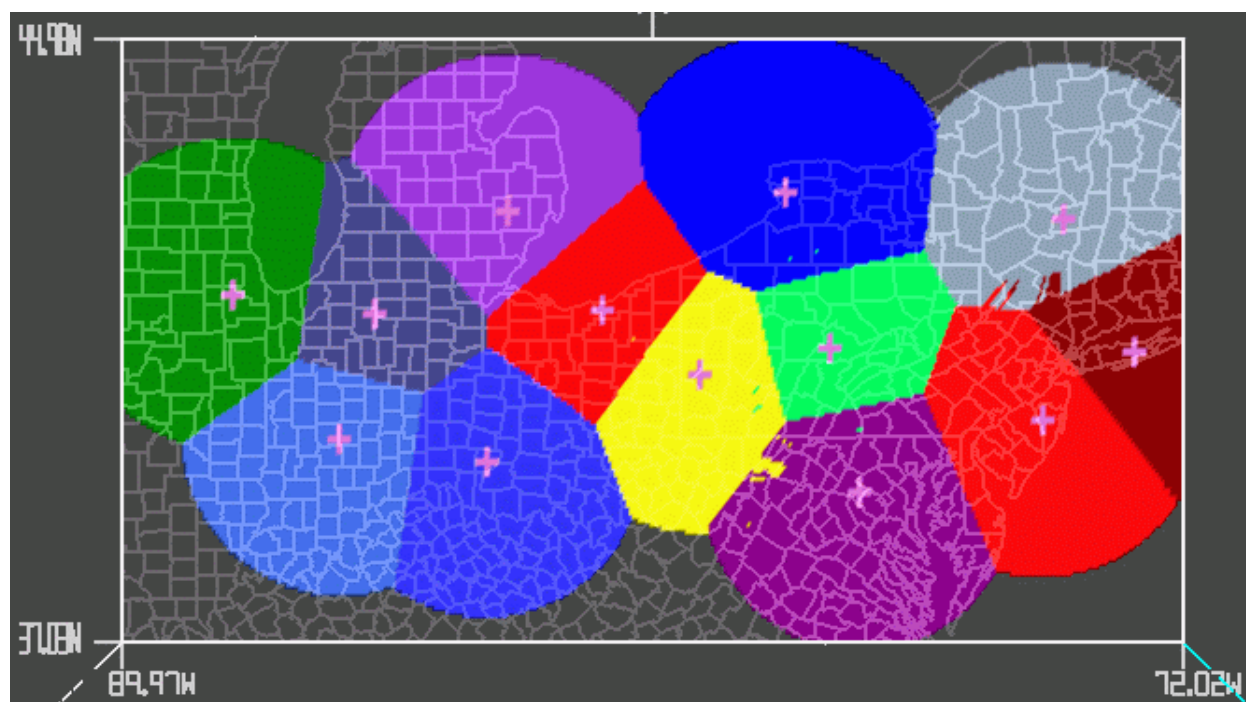


Figure 9. Initial analysis domain for the CIWS project. Each colored region indicates data from a separate WSR-88D.

posed that in real-time the 3D mosaic will be run in three sub-analysis domains (see Fig. 2) each covers one-third of the large target domain.  The sub-domain mosaic can be run in parallel as separate tiles. The results are patched together to obtain the final mosaic for the large domain.  Strategies for quantitatively esti-mating computational cost (i.e., CPU and RAM) of the 3D mosaic algorithm have been developed.

A request has been sent to MIT/LL asking for possible real-time radar data feeds from the northeast corridor WSR-88Ds to the NSSL.

b) Planned Efforts

Generate reference data sets for the 3D mosaic (i.e., terrain, polar-to-Cartesian and Cartesian-to-polar transformation matrixes, etc).  Estimate computational cost for the 3D mosaic scheme for various weather situations/platforms.
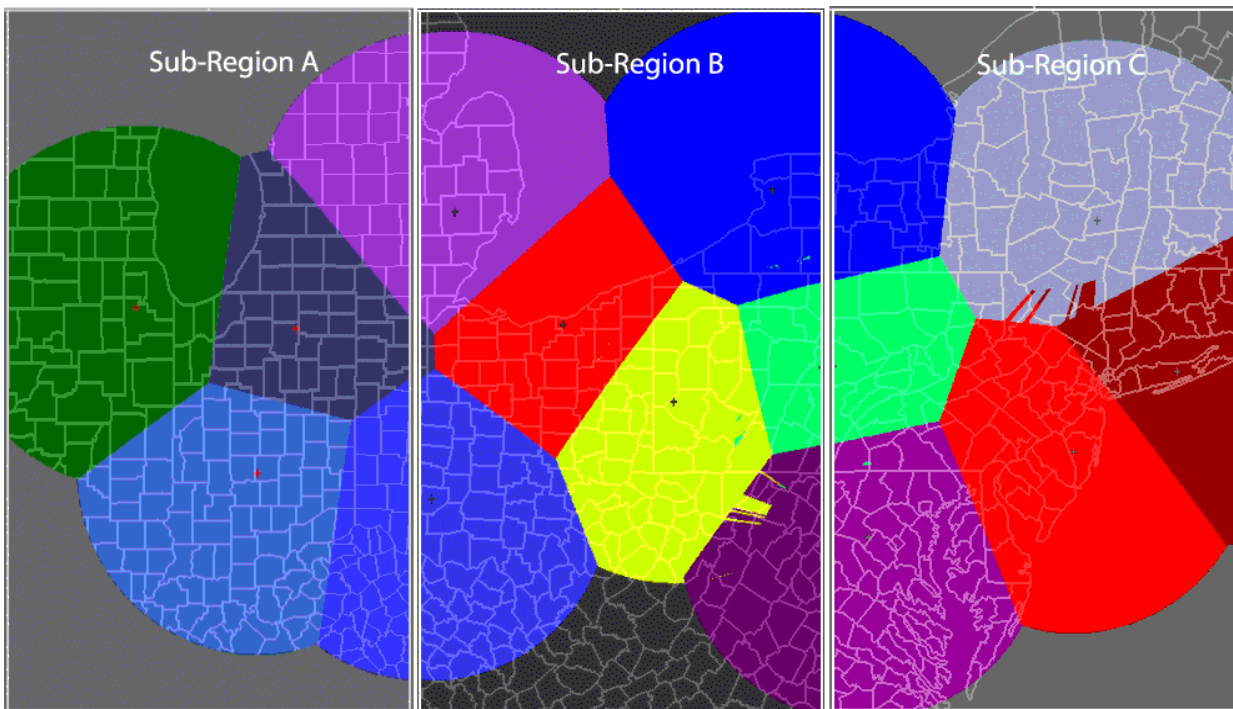
c) Problems/Issues

None.

Figure 10. Same as Fig. 1, but subdivided into the sepaarte analysis tiles that will be assembled to build an analysis of the CIWS region.

d) Interface with other Organizations

Had conference calls with the CWPDT (NCAR and MIT/LL). Provided example 3-D mosaic data sets, decoder, and documentation to the CWPDT. Requested real-time data feeds from MIT/LL.

e) Activity Schedule Changes

Needed schedule changes:

Tasks 02.6.14.4 (setup the analysis domain for the FAA northeast corridor) and 02.6.14.5 (archived case studies for the CIWS region) need to be moved forward. Task 02.6.14.1 (computational cost estimation) is delayed for about 1 month, so that the computational cost for running the 3D mosaic for the FAA domain can be assessed. This rearrangement is necessary so that the tasks will be accomplished in a consistent way.

**02.6.15  WARP Activities**
*Develop strategies and algorithms to remove meteorologically insignificant artifacts; develop next-generation WARP products, based on multi-radar gridded data, suitable for display to air traffic controllers.*

a) Current Efforts

is being collected for evaluation of the Unisys AP/Ground Clutter mitigation techniques. Enough data has been collected so that emphasis can now shift to the evaluation portion of the project. Data sets have been identified through previous AP mitigation studies found in literature. In addition, quite a few AP cases have been located within the WSR-88D's Hotline Assistance Request archive. Hotline Assistance Requests are documented and possible solutions to user requests are noted. There have been several cases in which assistance was requested for both meteorological and non-meteorological AP problems. Problems documented included ground clutter, chaff, electromagnetic interference, birds, bugs, smoke, volcanic eruptions, sea clutter, temperature inversions, and convective outflows.

b) Planned Efforts

A list has been compiled of WSR-88D cases, which contain AP problems. These cases will be examined to determine if they can be used in this study.

1) Amarillo, TX - 5/24/1995
2) St. Louis, MO - 7/3/1997
3) Ft. Hood, TX - 6/27/2001
4) Lake Charles, Shreveport, LA - 6/7/2001
5) Memphis, TN - 8/11/2000
6) Houston WSFO, 7/6/1992 09:49 UTC
7) Houston WSFO, 9/24/1992, 09:07 UTC
8) Goodland WSO, 12/23/1992, 11:40 UTC
9) Dodge City WSO, 3/8/1993, 07:53 UTC
10) Amarillo WSO, 5/4/1993, 17:20 UTC
11) Miami WSFO, 11/2/1993, 21:28 UTC
12) Milwaukee WSFO, 11/29/1994, 14:00 UTC
13) Green Bay WFO, WI, 2/19/1997, 14:45 UTC
14) QuadCities/Davenport, 7/1/1998, 13:10 UTC
15) Beale AFB, 7/28/98, 14:23 UTC
16) Great Falls, MT, 11/16/1998, 18:40 UTC
17) Washington DC CWSU, 12/11/1998, 15:00 UTC
18) South Shore, HI, 8/16/2001, 12:21 UTC

Level-II data from these cases will be converted to Level-III format and input into Unisys software used to evaluate the AP mitigation algorithms. When converting from Level-II to Level-III data, care will be taken to use the latest set of adaptable parameters associated with the Anomalous Propagation Removed (APR) product.

c) Problems/Issues

None.

d) Interface with other Organizations

None.

e) Activity Schedule Changes

None.